DOCUMENT RESUME

ED 305 526 CG 021 536

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TITLE Problem Solving and the Development of Expertise in Management.
PUB DATE 12 Aug 88
NOTE 24p.; Paper presented at the Annual Meeting of the American Psychological Association (96th, Atlanta, GA, August 12-16, 1988).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Administrators; *Cognitive Style; *Educational Attainment; *Employment Experience; Foreign Countries; Intelligence; *Knowledge Level; *Problem Solving
IDENTIFIERS Ontario

ABSTRACT

This study investigated novice and expert problem solving behavior in management to examine the role of domain specific knowledge on problem solving processes. Forty-one middle level marketing managers in a large petrochemical organization provided think aloud protocols in response to two hypothetical management scenarios. Protocol analysis revealed two levels of processing: novice-like processing characterized by serial, piecemeal problem solving, and expert-like processing identified by retrieval of prior knowledge and elaboration of the problem context. Multiple linear regression analysis demonstrated these processing categories to be strongly correlated to level of education and years of managerial experience but not significantly related to general intelligence measures. These findings parallel those of research in other domains. It was concluded that expertise in managerial problem solving is not directly related to general intellectual competencies but rather to the quantity and structure of acquired knowledge within this domain. (Author/NB)

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PROBLEM SOLVING AND THE DEVELOPMENT OF EXPERTISE IN MANAGEMENT

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Presented at the 96th Annual Convention of the American Psychological Association at Atlanta, Georgia, August 12, 1988, Friday, 10:00 a.m.

Abstract

Forty-one managers provided think aloud protocols in response to two hypothetical management scenarios. Protocol analysis revealed two levels of processing: novice-like processing characterized by serial, piecemeal problem solving, and expert-like processing identified by retrieval of prior knowledge and elaboration of the problem context. Multiple linear regression analysis demonstrated these processing categories to be strongly correlated to level of education and years of managerial experience but not significantly related to general intelligence measures. These findings parallel those of research in other domains. It was concluded that expertise in managerial problem solving is not directly related to general intellectual competencies but rather to the quantity and structure of acquired knowledge within this domain.

Problem Solving and the Development of Expertise in Management

Introduction

This study investigated novice and expert problem solving behaviour in management. The primary focus was on the role of domain specific knowledge on problem solving processes.

Recent finding from studies examining the problem solving behaviours of experts and novices in a number of domains indicate that expertise is closely related to the quantity and organization of domain specific knowledge. Areas have included the social sciences (Voss, Tyler, & Yengo, 1983; Voss, Greene, Post, & Penner, 1983), computer programming (Adelson, 1981, 1984), physics (Larkin, McDermott, Simon, & Simon, 1980; Chi, Glaser, & Rees, 1982) and chess (Chase & Simon, 1973).

Reviewing a series of studies on expert and novice problem solving in physics, Larkin, McDermott, Simon, and Simon (1980) concluded that experts and novices differ in at least five significant ways.

1. Experts solve problems faster than novices.
2. Novices tend to use "working backward" strategies, using goals and subgoals to direct their search for a solution. Experts tended to use a simpler "working forward" strategy, beginning with known quantities and accumulating knowledge as they worked through a problem. This leads leading directly to the third distinction.
3. Productions by novices appear to be not well integrated, containing general conditions and requiring tests against goals to proceed. Experts' productions appear to possess automated solution procedures that do not require repetitive testing.
4. Experts appear to store physics equations in integrated chunks, in contrast to novices who appear to store physics equations individually. This indicates that solutions are stored differently in experts and novices.
5. Finally, novices appeared to translate problem statements syntactically, creating problem representations organized around surface features of the problem statement. Experts, however, generate representations based on abstract physics principles.

The findings of other research point to the same conclusion. Novice problem representation is based on surface features where solution strategies are closely related to the objects in the task environment. As a result, the strategy employed by novices resembles "pure" analytical problem solving in novel task environments. Incidentally, it is this form of problem solving which is heavily emphasized in the management context.

In contrast, experts are able to use literal cues to evoke stored productions that specify solution paths. These experts possess a rich, hierarchically organized knowledge base indexed by patterns of problem features. These patterns are context bound and are acquired only through repeated experience in a problem domain. The knowledge base restricts search behaviour during problem solving. This allows the expert to utilize a forward moving strategy, in contrast to the novice who must decide the appropriate next moves at each node within the problem space.

Expertise in Management

Management is a context where few investigations have examined expertise from a knowledge based perspective. Wagner and Sternberg (1986), for example, found that expert managers "differ from novices primarily in the amount and organization of their knowledge about the task, rather than in their underlying cognitive abilities" (p. 54).

In the few studies that have actually examined how expert managers solve problems, the emerging picture parallels the findings of problem solving studies in other domains:

> They [senior managers] seldom think in ways that one might simplistically view as rational... they rarely systematically formulate goals, assess their worth, evaluate the probabilities of alternative ways of reaching them, and choose the path that maximizes expected return (Isenberg, 1984, p. 82).

Senior managers are usually preoccupied with only one or two abstract or general issues that subsume a larger number of specific problems. Among the twelve managers Isenberg interviewed the dominant problem solving technique was that of "intuition" or, cast in cognitive terms, highly automated domain specific procedures. These abilities enabled managers to bypass a more cognitively demanding problem analysis. Among the more interesting findings was that senior managers often used their own intuition "as a check... on the result of a more rational analysis" (p. 86).

In a more recent study Isenberg (1986) compared think aloud protocols of managers and students solving short business scenarios. Isenberg found that "managers used their experience rather than additional case information to interpret quite heavily from the presented information" (p. 784). The results of these studies indicate that experienced managers possess a rich and organized knowledge base which they utilize while solving problems. Based on these qualitative observations, problem solving expertise in management can be described as a foreword search through a problem space guided by pattern recognition and automated productions.

This view of managerial expertise stands in marked contrast to the conventional rationally based problem solving models emphasized in management training. This literature (see: Maccrimmon & Taylor, 1976; Davis, 1973; Van Gundy, 1981) is almost completely silent on evidence that effective managers actually engage in analytical problem solving. The component strategies of these models have included means-end analysis (Newell & Simon, 1972), lateral thinking (deBono, 1970), and structured problem analysis (Kepner & Tregoe, 1976).

The analytic emphasis of these models is more characteristic of the serial processing strategies employed by subjects in novel domains. In this respect, emergent research in decision theory and managerial information processing continues to emphasize model testing (e.g., Baye's theorem, allocation of effort) while diminishing or completely ignoring the cognitive processes used by managers in actual decision making contexts (Ungson, Braunstein, & Hall, 1981). Specifically, there is "a need to better understand higher-order mental processes as used by ... managers. How are prior conceptions applied in any particular situation? How are these prior conceptions formed via experience ?" (Isenberg, 1986, p. 785). Several questions remain largely unanswered, in particular, general arguments concerned with cognitive approaches to problem solving and specific issues focused on the management context.

The study of ill-structured problems is not a well researched domain in cognitive psychology. Areas in which problem solving has been investigated, including physics and mathematics, are domains in which knowledge is already highly structured and solutions are well known. Management represents a domain where problems are typically ill-structured, where few solutions are known and implementation and feedback are often delayed. As ill-structured problems resemble problems individuals face in daily life,

research into the process has important implications for the fields of cognitive theory and problem solving.

Within the domain of management a better understanding of the development of expertise and the knowledge upon which it depends could lead to more effective training and selection practices. These insights could indicate what kinds of knowledge are critical to expertise and how its acquisition can be facilitated.

Finally, questions remain on the validity of verbal protocols as a means of accurately describing a manager's decision process (Schweigher, 1983). Additional research is needed to establish verbal protocol analysis as a legitimate data gathering tool amenable to rigorous analysis.

Objectives

The present exploratory study was designed to further investigate the cognitive processes in managerial problem solving. The research sought to achieve four main objectives:

1. Identify expert and novice thought processes from think aloud protocols of business managers solving typical work related situations.

2. Describe the representation of knowledge in expert managers.

3. Identify the relationship between expert and novice problem solving processes and a set of key criterion measures. These measures include years of managerial experience, general intellectual ability, creativity, education, and age.
   At a more general level this study also explored the way in which domain specific knowledge affects problem solving behaviour. In particular, this research also examined the assumption that experience leads to a decreased search for information.

4. Establish the validity of verbal protocol analysis as a legitimate measure of managerial problem solving processes.

Methodology

Subjects

In contrast to most expert/novice research, this study made no a-priori distinctions between expert and novice subjects. A single, heterogeneous sample of 41 middle level marketing managers in a large petrochemical organization participated.

Criterion Measures

In previous managerial research significant relationships have been reported between managerial success and university grade point average (Weinstein & Srinivason, 1974) and a number of personality and intellectual factors (e.g., Harrell & Harrell, 1973). Few investigations, however, have examined in detail the association between concurrent cognitive processing in managerial problem solving and objective criterion measures. The establishment of such relationships is critical for the prediction of successful performance.

The volume of empirical evidence points to the conclusion that expertise depends on a complex interaction between general abilities collectively called "intelligence" and domain specific knowledge. Consequently, a primary goal of the present investigation was to assess the contribution of general intellectual abilities to expertise.

To investigate this relationship, two measures of general cognitive ability were utilized, Raven's Standard Progressive Matrices, and the A.C. Test of Creative Ability. The A.C. Test was developed by the A.C. Spark Plug Division of General Motors (1953-1960) as a measure of creative thinking. Subject's Age, Level of Education, and Total Years of Management experience made up the remainder of the criterion measures.

Procedure

The study was conducted as part of a three day marketing conference. Subjects were asked to volunteer to participate in a study investigating how managers solved problems. The Raven's Progressive Matrices and A.C. Test of Creative Ability were administered on a group basis. After completion of the formal testing, participants were withdrawn on a individual basis to provide think aloud protocols.

Managers were told that they would be thinking aloud while working on two hypothetical problem situations specific to their organization. Subjects were responsible for the operation of several company operated and independently owned retail gasoline outlets. The first problem had a concrete/functional orientation. It was meant to be typical of the kinds of daily issues these managers faced.

Scenario 1

> A recent worker satisfaction study was done at stations in your region. The study concluded that most employees are not as happy as they would like to be. You have been wondering what to do about the situation. Think out loud as you consider how you would go about solving this problem.

The second scenario was more abstract in its emphasis, lacking the clear problem focus of the first scenario. The goal is also more abstract, being related to corporate values and mission, presenting an issue more familiar to senior level managers.[1]

Scenario 2

> The new vice president of marketing has challenged managers and employees alike to increase the image of our company and dealer operated gasoline outlets. In _____ _____'s own words, "What will it take to move our side of the operation towards excellence?" As a middle level manager in marketing how will you meet _____ _____'s challenge? Remember to think aloud as you work through this problem.

Subjects were first read an introduction to the concept of thinking aloud by the test administrator and were then given two practice problems. The experimenter then read through scenario 1 with the subject. The problem scenario was removed from the subjects' view for the remainder of the interview. All subjects' responses were taped with their knowledge. Participants were prompted with neutral cues (e.g., "keep talking") if they remained silent for longer than ten seconds. The same procedure was followed with the second scenario. Each subject was allowed a maximum time limit of ten minutes to respond to each problem.

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[1] Names have been deleted from the present text

Analysis of Protocols

The analysis of protocols occurred in two sequential phases. The first phase involved the segmentation of protocols into categorizable units, and the development of category sets into which protocol segments could be coded. In the second phase of analysis individual protocol categories were combined to yield two dependent measures of novice and expert processing for each protocol.

All protocols were transcribed verbatim and segmented into individual units or propositions. Two raters independently unitized a sample of protocols. An acceptable level of reliability was obtained by using measures established by Guetzkow (1950).

Qualitative Analysis

Most expert/novice studies (e.g., Chi, Glaser, & Rees, 1982; Chase & Simon, 1973; Goor & Sommerfield, 1975; Greeno, 1978; Isenberg, 1987; Wagner & Sternberg, 1986) have used age, grade level, and years of experience to distinguish experts from novices. Since the present study had no a-priori distinctions the protocol data itself defined these differences. These distinctions were based on the notions of domain specific retrieval oriented strategies and domain general search oriented strategies.

Problem 1 protocols served as the basis for the development of the coding scheme. This allowed for the validity of the coding scheme to be independently tested using problem 2 protocols. The first step in the development of a coding scheme was to perform a qualitative analysis of a sample of protocols for general patterns in verbal behaviour.

The following protocol segment (subject S.E.) exemplifies the use of sequential search for additional information to guide problem solving:

1. O.K. So the employees are not as happy as they'd like to be.
2. First of all you have to find out what they're not happy about.
3. And once we found out what they're not happy about, figure out what can be done to make them happy about whatever we have to do in our powers to make them happy.
4. And if we can't solve it maybe we can uh...
5. And if we can't solve that particular problem that's making them angry, maybe we

can build or add to other areas that they like.

6. Maybe it'll even them out.
7. But I think the best thing to do is to find out what's bothering them the most.
8. Do a study and find out.
9. Maybe we can write down some uh, some headings the problems of employees in gas usually have.
10. First of all you've got to find out what is wrong with them.
11. You can't really go on any further until you find out what's wrong.

This subject begins by encoding with minimal interpretation the surface features of the problem statement (verbalization 1) and then engages in a piecemeal identify cause/identify solution strategy (verbalizations 7-11). The problem representation generated is extremely limited, containing only the main components of the given problem statement. Subject D.M. shows a similar deficit:

1. The number one problem for most people seems to be money.
2. The first thing I do is I look down the raise scale and I would give people a raise as I see fit.
3. I try to get the group together in a happy environment.
4. Take them out to dinner.
5. Try to get on a one-to-one, more friendly personal basis.
6. And then I would take them aside and ask them what problems they have.
7. And discuss what I can do to help them.
8. There is probably a lot of personal problems.
9. Unfortunately there is not much you can do about that except talk it out.
10. I would try to get to know a person off the business level and down to one-to-one personal level.
11. If he has problems then I could tell him my experiences.

Most of this protocol present a number of low-level solutions (e.g., giving a raise) which are linked to a few specific unrelated causes (money, personal problems). The argument development is also serial, progressing through the steps involved in the implementation of a solution that is limited in scope (verbalizations 3-7).

The strategies in both these protocols is similar to those used by novices solving social science problems (Voss, Tyler, & Yengo, 1983). Those protocols were characterized by

an underdeveloped problem representation and the listing of solutions "without any consideration of the constraints on, or orientations to, the solutions proposed" (p. 217).

In the more expert-like protocols subproblems and solutions are more abstract and are supported by the retrieval of prior knowledge, as shown in the following two protocol segments:

1. I think it is a problem.
2. I think there's probably more solutions to it than I would understand.
3. I think we have to get back to basics.
4. And let the employees know how important they actually are.
5. I don't know but when I pumped gas you felt left out.
6. You felt left out of the mainstream.
7. You felt not recognized.
8. You felt like, you know, you're there pumping gas and no one gives a damn.
9. Actually, if it wasn't for the people pumping gas we wouldn't be here.
10. I wouldn't be here, no-one would be here.
11. I think we have to get them more involved with the company.
12. I think our pay structure is totally out of line.
13. Both with other companies.
14. And with the normal work that's being done.

Instead of entering into a description of steps, subject D.D. spends a greater percentage of time developing and elaborating the problem representation before specific causes or solutions are proposed. This is accomplished through the retrieval of relevant personal cases (verbalizations 5-8), general management principles (verbalizations 9-10), and the general corporate situation (verbalizations 12-14). Subject M.A. shows a similar strategy:

1. Other issues the employees may not be happy about is the service stations.
2. The conditions they have to work in.
3. Some of the service stations require upgrading.
4. Dealing with old pumps that are frequently breaking down and malfunctioning.
5. Electronic consoles and self serves that are inaccurate to what the pump reading says.
6. Things as simple as the steno chair you're sitting on.
7. The wheels are broken and it doesn't roll out.
8. These are basically a lot of the issues that would make employees unhappy as far as

I'm concerned.

9. Probably a lot of those can be dealt with if we can find the source of what you're unhappy about.
10. I would say that probably 75 percent of those items I'd mentioned can be solved and quite frequently quite easily.
11. I'm thinking back now to when I had actual subordinates that worked for me.

This subject begins by proposing a cause related to working conditions in the service stations (verbalizations 1-2). Instead of immediately listing solutions, however, this statement of cause is developed through verbalizations 3-8. Personal cases are retrieved from long term memory in order to illustrate the reasons for the present situation. It is also clear that solutions are already known (verbalization 10) but are not explicitly stated. This may indicate that elaboration of the problem statement may serve to make solutions self evident. It is important to note that protocols exhibited the presence of both expert like processing (identified by the retrieval of information and elaboration of the problem context) and novice approaches (characterized by a greater degree of information search and problem decomposition).

Category Sets

A coding scheme was consequently developed to quantify inferences of expert and novice problem solving processes. To minimize the risk of biasing data to fit with theory, coding categories were derived directly from the verbal data themselves wherever possible.

Problem 1 protocols served as the basis for the development of the coding scheme. This allowed for the validity of the coding scheme to be independently tested using problem 2 protocols. Based on these preliminary observations a coding scheme was constructed for problem 1 which reflected both protocol content as well as theoretical expert/novice processing distinctions. The scheme consisted of eleven major categories. A detailed description of each category is provided in Tables 1 and 2.

Insert Tables 1 and 2 about here

Novice categories were represented by domain general knowledge (1.0: Principles of Management), a search for missing information without the retrieval of prior knowledge (2.0: Working on a Hypothesis; 3.0: Solutions as Problems to be Solved, and 4.0: Working on Solutions), and a focus on the surface features of the problem statement (5.0: Repeating Given Problem Constraints, and 6.0: Task Related Statements).

In contrast, expert categories were defined by the retrieval of prior knowledge (7.0: Historical Cases; 8.0: Corporate Climate), verbalizations of known causes and solutions (9.0: Generating Hypotheses; 10.0: Solutions as Expected Outcome), and the ability to organize information (11.0: Summarizations). Protocols were independently coded by two raters. Level of interrater accuracy was .75.

In the next phase of analysis the relative frequencies from novice categories were combined. This new statistic gave a quantitative measure of the relative frequency of novice verbalizations for each subject's protocol. The same procedure was repeated for expert categories.

Results

Response Frequencies By Problem

The coding scheme developed for problem 1 worked equally well for coding statements in problem 2. Verbalizations in problem 1 tended to focus on the identification of causes for worker unhappiness (2.0: Working on a Hypothesis and 9.0: Generating Hypotheses) (see Table 3).

Insert Table 3 about here

In contrast, a greater emphasis on solutions and corporate issues characterized verbalizations in problem 2 (4.0: Working on a Solution and 8.0: Corporate Climate).

These results would be expected, given that problem 1 was perceived as a search for causes as opposed to problem 2 which centered on the improvement of corporate image.

Correlation of Criterion Measures

Pearson correlation coefficients showed that total years of management experience correlated positively with Age (r = .63) and negatively with Raven's scores (r = -.43) and Education (r = -.47). These findings indicate that many of the experienced managers are older, less abstract in their reasoning, and less educated than their younger counterparts. In general, more experienced managers may have bypassed a formal educational route. Many of these managers were drawn to "front line" jobs such as gas bar attendant which required no formal education or experience.

Multiple Linear Regression Analysis

To assess the contribution of each criterion measure in predicting Expert and Novice verbalizations, multiple linear regression analysis was performed on each problem.

Neither Raven scores nor A.C. Creativity scores had a significant relationship to Expert and Novice categories in either problem. The lack of obtained relationship between processing categories and general intellectual and creative abilities points to the conclusion of problem solving research in other domains. Specifically, these findings indicate that expertise in problem solving is not directly related to intellectual competencies but rather to acquired knowledge within a domain.

In problem 1 Education had the highest correlation with novice processing, r = .48, p<.001, n = 28. Education also emerged as the key predictor for Expert processing in problem 1, r = -.55, p<.01, n = 28. In problem 2, Management Experience correlated negatively with Novice processing, r = -.41, p<.05, n = 28. Management Experience was also highly correlated with expert categories, r = .43, p<.05, n = 28 [2].

Consequently, Education was the significant predictor of Novice and Expert processing in problem 1, whereas Management Experience was the critical predictor in problem 2. One explanation for these results may be that the problems require two different types of

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[2] The drop in the total number of subjects in this analysis was due to the combined effect of missing A.C. Creativity test scores and years of Management Experience for some subjects.

knowledge bases for effective solution. Problem 1, characterized by an undesirable situation and a reasonably clear but implicit goal, resembles typical problems faced in a variety of work related situations. These problems would not be typically faced in formal educational settings. Problem 2 was more abstract, reflecting the kinds of issues senior managers might face in strategic planning. Therefore, Education and Management Experience may be important limiting factors in the development of two different types of knowledge bases.

General Discussion

Structure of the Knowledge Base

In both problem scenarios more expert like subjects developed an overall context for the problem and proposed solutions through the retrieval of prior knowledge. In problem 1, more expert like subjects would often begin by establishing a few abstract hypotheses and provide historical or corporate climate statements to develop arguments around proposed causes. The knowledge base of these subjects appears to consist of accumulated episodes and events experienced within the company. As experience accumulates, critical features of events become organized around common issues such as wage problems or working conditions. This enables the more expert like manager to rapidly match common patterns in the work context to existing cognitive structures without engaging in lengthy problem analysis.

In contrast, the solution process of more novice like subjects depicted a search for unknown factors and the piecemeal application of general solution procedures. This same pattern of results was found between experts and novices solving physics problems (Chi, Glaser, & Rees, 1982). Based on these findings it is possible to conclude that increased experience leads to a decreased search for information.

Implications for Protocol Research

The significance of this research is that one can use the findings derived from the cognitive literature to create protocol coding schemes that build upon a theory of expertise in a new domain. An important methodological issue in protocol research is the possibility of contaminating data with theory and the difficulties this presents in the move from qualitative to quantitative research. As a result of this study a number of recommendations are warranted.

The first recommendation relates to methodological design. Verbal data itself should be allowed to determine protocol categories. In the present study the objectivity of the result is supported by the use of a heterogeneous subject pool that had no a-priori expert/novice distinctions. The data determined these differences. In other investigations where experts and novices are preselected, data are already heavily biased.

A second recommendation is that a careful and detailed reading of a selected sample of protocols precede attempts to develop category sets. Coding is then facilitated as the content of protocol statements will be partially reflected in category sets.

Implications for Training

Given that the structure of knowledge is critical to the development of expertise more attention should be focused on the acquisition of knowledge rather than pure analytical skill (see, for example, Collins & Stevens, 1982; Collins, Brown, & Newman, in press; Glaser, 1984; Greeno, 1978; Larkin, McDermott, Simon, & Simon, 1980; Norman, Gentner, & Stevens, 1976; Resnick, 1985; Scandura, 1981; Voss, 1978).

The training in problem solving skills in management has traditionally focused on teaching analytical problem solving models, which in light of the present investigation, may only encourage and perpetuate novice like strategies. Many experienced managers often treat these approaches with skepticism, as it runs counter to their preferred mode of processing. These approaches rely more on "intuition" and pattern recognition.

At the most general level these results indicate that knowledge should be acquired within the context of its use. In instructional design, efforts should be made to identify the patterns of conditions or cues which influence the flow of problem solving throughout the task. This requires a shift in focus from an analysis of the task and its component skills and subskills to an analysis of the individual performing the task. Having subjects 'think out loud' while performing a task is a useful tool in identifying the structure of knowledge and important problem features in the actual job context. In the development of instructional materials basic patterns of problem features identified in the instructional design phase can then be highlighted. This would help to encourage pattern recognition ability (e.g., Collins, Brown, & Newman, in press; Lash, 1984).

By focusing on one problem rich domain, this study has demonstrated that the organization of expert knowledge in management and the cognitive processes that arise from it parallels those processes of other problem-rich domains. As studies of this nature continue and refinements in research techniques develop, the invariant properties underlying real life activity will continue to emerge. This will open the path to technologies that will aid in the improvement of daily performance.

Table 1

Novice Protocol Coding Categories

Category	Title	Description
1	Principles	Subject recalls facts based on general principles of management and human behaviour.
2	Working on a Hypothesis	Subject describes the steps or procedures in the search for additional information
3	Solution as Problem to be solved	Example: We're going to have to find a way to increase wages.
4	Working on a Solution	Subject describes the steps or procedures in the implementation and evaluation of a specified solution.
5	Problem Constraints	Subject repeats or interprets given problem statements directly or paraphrases.
6	Task Related Statements	Statements directed at the experimenter relating to the problem solving task itself.

Table 2

Expert Protocol Coding Categories

Category	Title	Description
7	Historical Cases	Subject recalls statements of specific events or situations as they relate to experiences within the company
8	Corporate Climate	Subject recalls general corporate facts as they relate to current attitudes and concerns within the company.
9	Generating Hypotheses	Subject advances a possible cause or factor that produces the present situation.
10	Solution as Expected Outcome	Example: Give them more responsibility, increase their wages.
11	Summarizations	Subject provides a summary of the protocol up to that point.

Table 3

Average Frequency Response by Category for Problem 1 and 2

	Category										
	1	2	3	4	5	6	7	8	9	10	11
Problem											
1	3.7	11.0	2.7	10.0	0.6	2.4	8.3	3.5	3.1	3.7	0.7
2	3.0	5.4	2.8	20.4	1.1	2.2	7.3	8.5	1.3	5.9	0.6

n = 41

References

Adelson, B. (1981). Knowledge structures of computer programmers. In *Proceedings of the Fourth Annual Meeting of the Cognitive Science Society*, 4 (243-248).

Adelson, B. (1984). When novices surpass experts: The difficulty of a task may increase with expertise. *Journal of Experimental Psychology: Learning Memory, and Cognition*, 10 (3), (483-495).

Chase, W.C. & Simon, H.A. (1973). Perception in chess. *Cognitive Psychology*, 4, 55-81.

Chi, M.T.H., Glaser, R., & Rees, E. (1982). Expertise in problem solving. In R. Sternberg (Ed.), *Advances in the psychology of human intelligence*. Hillsdale, N.J.: Earlbaum.

Collins, A., Brown, J.S., & Newman, S.E. (in press). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics. In L.B. Resnick (Ed.), *Cognition and Instruction: Issues and agendas*. Hillsdale, N.J.: Earlbaum.

Davis, G.A. (1973). *Psychology of problem solving: Theory and practice*. New York: Basic Books.

deBono, E. (1970). *Lateral thinking: Creativity. Step by step*. New York: Harper & Row.

Glaser, R. (1984). Education and thinking: The role of knowledge. *American Psychologist*, 39 (2), 93-104).

Goor, A. & Sommerfield, R.E. (1975). A comparison of problem-solving processes of creative and noncreative students. *Journal of Educational Psychology*, 67 (4), 495-505.

Greeno, J.G. (1978). A study of problem solving. In R. Glaser (Ed.), *Advances in instructional psychology*. Hillsdale, N.J.: Earlbaum.

Guetzkow, H. (1950). Unitizing and categorizing problems in coding qualitative data. *Journal of Clinical Psychology*, 6 (1), 47-58.

Harrell, T.W. & Harrell, M.S. (1973). The personality of MBA's who reach general management early. *Personnel Psychology*, 26, 127-134.

Isenberg, D. (1986). Thinking and Managing: A verbal protocol analysis of managerial problem solving. *Academy of Management Journal*, 29 (4), 775-788.

Isenberg, D. (1984). How managers think. *Harvard Business Review*, 54 (6), 81-90.

Kepner, C.H., & Tregoe, B.B. (1976). *The rational manager*. Princeton, New Jersey: Kepner-Tregoe Inc.

Larkin, J., McDermott, J., Simon, D.P., & Simon, H.Ag. (1980). Expert and novice performance in solving physics problems. *Science*, 208, 1335-1342.

Lash, F.B. (1984). *Intentional cognition in the training of piano skills: A case study*. Unpublished course paper.

Maccrimmon, K.R. & Taylor, R.N. (1976). Decision making and problem solving. In M. Dunnette (Ed.), *Handbook of industrial and organizational psychology*. Chicago: Rand McNally.

Newell, A. & Simon, H.A. (1972). *Human problem solving*. New York: Prentice Hall.

Norman, D.A., Gentner, D.R., & Stevens, A.L. (1976). Comments on learning schemata and memory representation. In D. Klahr (Ed.), *Cognition and instruction*. Hillsdale, N.J.: Earlbaum.

Resnick, L.B. (1985). Cognitive Science and instruction. Paper presented at a meeting of the American Association for the Advancement of Science, Washington, D.C.

Scandura, J.M. (1981). Problem solving in the schools and beyond: Transition from novice to the neophyte to the master. *Educational Psychologist*, 16 (3), 139-150.

Schweigher, D.M. (1983). Is the simultaneous verbal protocol a viable method for studying managerial problem solving and decision making? *Academy of Management Journal*, 26 (1), 185-192.

Ungson, G.R., Braunstein, D.N., & Hall, P.D. (1981). Managerial information processing: A research review. *Administrative Science Quarterly*, 26 (1), 116-134.

Voss, J.G. (1978). Toward a cognitive theory of learning. In A.M. Lesgold, J. Pellegrino, S.D. Fokkema, & R. Glaser (Eds.), *Cognitive psychology and instruction*. New York: Plenum Press.

Voss, J.F., Tyler, S., & Yengo, L. (1983). Individual differences in social science problem solving. R.G. Dillon & R.R. Schmeck (Eds.), *Individual differences in cognitive processes*. New York: Academic Press.

Voss, J.F., Greene, T.R., Post, T.A., & Penner, B.C. (1983). Problem solving skill in the social sciences. In G. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory*. New York: Academic Press.

Wagner, R.K. & Sternberg, R.J. (1986). Tacit knowledge and intelligence in the everyday world. In R.G. Sternberg & R.K. Wagner (Eds.), *Practical intelligence. Nature and origins of competence in the everyday world*. New York: Cambridge University Press.

Weinstein, A. & Srinivason, V. (1974). Predicting managerial success of master of business administration (MBA) graduates. *Journal of Applied Psychology*, 59 (2), 207-212.